MIXER FOR LIQUID CHROMATOGRAPH

Background of the Invention

1. Field of the Invention

The present invention relates to a mixer for a liquid chromatograph and, in particular, to a mixer which is used to mix liquids together so as to make an eluent for gradient analysis.

2. Description of the Related Art

In a liquid chromatograph, there is made a gradient analysis in which the composition of an eluent is caused to vary continuously or in a stepped manner. In the gradient analysis, in order that two or more kinds of liquids are mixed together to thereby introduce a column as an eluent, a gradient eluting apparatus includes a mixer for mixing a plurality of liquids together. As the mixer, there is often used an apparatus of a flow-through type which does not include a movable part; for example, there is known an apparatus structured such that balls made of stainless steel are loaded into a pipe having an inside diameter of about 3 mm and a length of about 50 mm. This type of mixer is composed of a plurality of machined parts such as entrance and exit machined parts. In the case of such mixer, since balls for mixing are loaded into the interior of the mixer, the internal capacity thereof is large. In order to mix together the plurality of liquids with high efficiency,

there is required the optimum mixer capacity according to the flow quantities of the liquids; however, a flow passage for such mixture depends on the balls loaded into the interior of the pipe, which makes it impossible to form a desired flow passage. In addition, this type of mixer is complicated in machining and assembling, which results in the high cost thereof.

Summary of the Invention

The present invention aims at eliminating the above-mentioned drawbacks found in the related-art mixer. Accordingly, it is an object of the invention to provide a mixer which can provide excellent mixing performance, can be reduced in size, and can change the mixing capacity thereof easily.

In attaining the above object, according to the invention, there is provided a mixer for a liquid chromatograph comprising:

a connected body including a plurality of plate materials connected together so as to form therein flow passages serving as a mixing portion, the connected body including at least two liquid supply holes for supplying liquids to the flow passages and a take-out hole for taking out the liquids mixed together from the flow passages,

wherein two or more plate materials each including a flow passage are superimposed on top of each other and two or more of the flow passages are connected in parallel to each other.

The series connection of the mixing portions is unable

to enhance the liquid mixing efficiency sufficiently and, in order to be able to enhance the liquid mixing efficiency sufficiently, the mixing portions must be connected in parallel to one another. According to the invention, by superimposing a plurality of plate materials on top of one another, each having a flow passage serving as a mixing portion therein, the flow passages can be connected together in parallel. For the parallel arrangement of the flow passages, there may be used three plate materials as a set. That is, a first plate material has penetration holes for supply of the liquids and a penetration hole for taking out the mixed liquids. A second plate material has penetration holes for supply of the liquids, a penetration hole for taking out the mixed liquids, and a flow passage for mixing the liquids together. A third plate material has penetration holes for supply of the liquids, a penetration hole for taking out the mixed liquids, and a flow passage for collecting the mixed liquids together. The penetration holes for supply of the liquids and the penetration holes for taking out the mixed liquids of the respective plate materials are formed at the same positions, thereby providing a structure in which these penetration holes penetrate through the three plate materials. A plurality of sets, each composed of the three plate materials, are connected together in such a manner that the penetration holes for supply of the liquids and the penetration holes for taking out the mixed liquids are set at

the same positions. Thanks to this, the respective sets (i.e., the mixing portions of the respective sets) can be connected in parallel to one another and, after the supplied liquids are mixed together in the flow passages of their respective sets, they can be collected together by the common take-out penetration hole.

Brief Description of the Drawings

Fig. 1 is a schematic structure view of an embodiment of a mixing portion formed in a mixer for a liquid chromatograph according to the invention;

Fig. 2 is a section view of a holder on which the mixing portions can be mounted; and

Fig. 3 is an explanatory view of a connecting method for connecting together a plurality of mixing portions.

Detailed Description of the Invention

Now, description will be given below in detail of the mode for carrying out the invention with reference to the accompanying drawings. Fig. 1 is a schematic structure view of an embodiment of a mixing portion of a mixer for a liquid chromatograph according to the invention. Three metal plate materials 1, 5, and 12 provide a basic structure for the mixing portion. The metal plate material 1 includes four penetration holes 2a - 2d and a positioning hole 4. The metal plate material

5 includes four penetration holes 6a - 6d, a positioning hole 8, and two flow passages 10a, 10b. The metal plate material 12 includes four penetration holes 14a - 14d, a positioning hole 16 and a flow passage 18. The metal plate materials 1, 5, and 12 are each a corrosion resistant metal plate (for example, SUS316) having a thickness of 2 mm or less. The positioning holes 4, 8 and 16 are all penetration holes and are respectively formed at the same positions in their associated metal plate materials 1, 5 and 12. Also, the penetration holes 2a - 2d, 6a - 6d, and 14a - 14d are respectively formed at the same positions in their associated metal plate materials 1, 5 and 12.

The metal plate materials 1, 5 and 12 are united together in this order, as a set, using the positioning holes 4, 8 and 16, at such determined positions that the penetration holes 2a - 2d, 6a - 6d, and 14a - 14d can penetrate through the three metal plate materials 1, 5 and 12; that is, there is formed a mixing portion. Further, a plurality of sets, each having the same combination of the metal plate materials 1, 5 and 12 forming the mixing portion, are united together at such determined positions that that the penetration holes 2a - 2d, 6a - 6d, and 14a - 14d can penetrate through their associated set of plate materials. Next, on the metal plate material 12 of the set of plate materials that are combined last, there is placed a flat plate including neither flow passage nor penetration hole. Two kinds of liquids are introduced from

the penetration holes 2a and 2b, and reach the penetration holed 6a and 6b, while the liquids in part flow to the flow passages 10a and 10b. The flow passages 10a and 10b are grooves which are formed so as to penetrate through the metal plate material 5. The liquids, which have flown through the flow passages 10a and 10b, meet together in the flow passage 18 so that the two kinds of liquids are mixed together. The flow passage 18 is a groove which has a bottom. The mixed liquids are allowed to flow from the penetration holes 14c and 14d and flow through the penetration holes 6c and 6d, and are taken out from the penetration holed 2c and 2d.

The liquids, which have passed through the penetration holes 2a, 2b, 6a, 6b and 14a, 14b of the mixing portion of a first set, are introduced in the penetration holed 2a and 2b of the mixing portion of a second set and reach the penetration holes 6a and 6b, while the liquids in part flow to the flow passages 10a and 10b. In the mixing portion of the second set as well, similarly to the mixing portion of the first set, the liquids are mixed together and, finally, the thus mixed liquids are taken out from the penetration holes 2c and 2d of the mixing portion of the first set. In the mixing portion of a third set as well, there is executed a similar operation.

A plurality of sets of mixing portions, each composed of the metal plate materials 1, 5 and 12, are disposed in a holder shown in Fig. 2. The holder comprises a connecting part

20 and a support part 21. The connecting part 20 includes four connecting ports 24a - 24d and a support part mounting portion 26. In the support part 21, there is formed a metal plate material mounting portion 22. After the plurality of sets of mixing portions, each composed of the metal plate materials 1, 5 and 12, are mounted on the metal plate material mounting portion 22, the support part 21 is mounted on the support part mounting portion 26 in such a manner that the connecting ports 24a - 24d and penetration holes 2a - 2d are matched in position to one another. Next, the connecting part 20 and support part 21 are fixed to each other using bolts 28 and 29, with the result that the metal plate materials 1, 5 and 12 provide an integrated connected body in such a manner that no bad condition such as liquid leakage can occur. The holder has a structure which can be disassembled easily and thus, when it is desired to change the capacity of the mixing portions due to variations in the flow quantities of the liquids, the metal plate materials 5 and 12 can be replaced easily.

Liquids, which that are introduced into N sets of mixing portions and are mixed together, can be taken out from the penetration holes 2c and 2d of the first set. Therefore, the respective sets are connected together in parallel as shown in Fig. 3 and thus, the liquids mixed in the respective sets are allowed to flow from the penetration holes 14c and 14d and pass through the penetration holes 6c and 6d and the penetration

holes 2c and 2d, and are then allowed to meet together, so that the liquids can be mixed with high efficiency.

The flow passages 10a, 10b and 18 can be formed by etching or by press working. By changing the thicknesses of the metal plate materials 5 and 12, or by changing the widths of the grooves of the flow passages 10a, 10b and 18, the capacity of the mixing portion can be changed easily; and, the flow quantities of the liquids can be changed easily simply by replacing the metal plate materials 5 and 12.

Although description has been given heretofore of the embodiment of the invention, the invention is not limited to the above embodiment but various changes are also possible without departing from the scope of the gist of the invention as set forth in the appended patent claim. For example, the number of metal plate materials including a flow passage formed therein is not limited to a specific one but a proper number of metal plate materials can be set according to mixing flow passages to be formed. Also, the shapes of the flow passages 10a and 10b are simply the illustration examples thereof and thus the shapes of the flow passages can be designed properly so as to be able to obtain a desired mixing condition. In case where the flow passages 10a and 10b are not penetration grooves but bottomed-grooves, the metal plate material 12 can be omitted and a connected body with a mixing portion composed of the metal plate materials 1 and 5 can be formed. In this case, in the

metal plate material 5, there is formed a flow passage being connected to the flow passages 10a and 10b to mix and correct the liquids flowing through the flow passages 10a and 10b.

According to the invention, there is provided a structure in which two or more plate materials each including a flow passage serving as a mixing portion are superimposed on top of each other and two or more flow passages are connected together in parallel to each other. Thanks to this, not only there can be obtained a high mixing performance but also the flow passages and the capacity of the mixing portions formed in the interior of the mixer can be changed easily. Further, since the mixer has a structure in which the plate materials are superimposed on top of each other, the number of parts can be reduced and thus the size of the mixer can be made compact.